FORM PTO-1390 (Modified) (REV 11-98) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER	
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U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR	09/786161

INTERNATIONAL APPLICATION NO	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/JP00/04401	03 JULY 2000	05 JULY 1999

TITLE OF INVENTION

METHOD, APPARATUS, COMPUTER PROGRAM, COMPUTER SYSTEM AND COMPUTER-READABLE STORAGE FOR REPRESENTING AND SEARCHING FOR AN OBJECT I N AN IMAGE

APPLICANT(S) FOR DO/EO/US

Miroslaw BOBER

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☐ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☒ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ A copy of the International Search Report (PCT/ISA/210).
8. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
9. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
10. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
11. ☐ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

Items 13 to 20 below concern document(s) or information included:

13. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☐ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☐ Certificate of Mailing by Express Mail
20. ☒ Other items or information:

Request for Consideration of Documents Cited in International Search Report
Notice of Priority
Drawings (6 sheets)
PCT/IB/308

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR) 09786161	INTERNATIONAL APPLICATION NO. PCT/JP00/04401	ATTORNEY'S DOCKET NUMBER 203524US2PCT

21. The following fees are submitted:.

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :

		CALCULATIONS PTO USE ONLY
☐	Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2) paid to USPTO and International Search Report not prepared by the EPO or JPO	$1,000.00
☒	International preliminary examination fee (37 CFR 1.482) not paid to USPTO but Internation Search Report prepared by the EPO or JPO	$860.00
☐	International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO	$710.00
☐	International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4)	$690.00
☐	International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4)	$100.00

ENTER APPROPRIATE BASIC FEE AMOUNT =	**$860.00**	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).	**$0.00**	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	28 - 20 =	8	x $18.00	**$144.00**	
Independent claims	5 - 3 =	2	x $80.00	**$160.00**	
Multiple Dependent Claims **(check if applicable)**.			☐	**$0.00**	
TOTAL OF ABOVE CALCULATIONS =				**$1,164.00**	
Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28) **(check if applicable)**.			☐	**$0.00**	
SUBTOTAL =				**$1,164.00**	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)). +				**$0.00**	
TOTAL NATIONAL FEE =				**$1,164.00**	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) **(check if applicable).**			☐	**$0.00**	
TOTAL FEES ENCLOSED =				**$1,164.00**	
				Amount to be: refunded	$
				charged	$

☒ A check in the amount of **$1,164.00** to cover the above fees is enclosed.

☐ Please charge my Deposit Account No. in the amount of to cover the above fees.
A duplicate copy of this sheet is enclosed.

☒ The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No. **15-0030** A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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SIGNATURE

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NAME

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REGISTRATION NUMBER

March 2 2001
DATE

203524US

IN THE UNITED STATES PATENT & TRADEMARK OFFICE

IN RE APPLICATION OF :

MIROSLAW Z. BOBER : ATTN: APPLICATION DIVISION

SERIAL NO: NEW U.S. PCT APPLICATION :
(Based on PCT/JP00/04401)

FILED: HEREWITH :

FOR: METHOD, APPARATUS, COMPUTER PROGRAM, COMPUTER SYSTEM AND COMPUTER-READABLE STORAGE FOR REPRESENTING AND SEARCHING FOR AN OBJECT IN AN IMAGE

PRELIMINARY AMENDMENT

ASSISTANT COMMISSIONER FOR PATENTS
WASHINGTON, D.C. 20231

SIR:

Prior to a first examination on the merits, please amend the above-identified application as follows:

IN THE CLAIMS

Please cancel claims 1-22 without prejudice.

Please add new claims 23-50 as follows:

--23. (New) A method of representing an object appearing in a still or video image, by processing signals corresponding to the image, the method comprising deriving a plurality

of numerical values representing features appearing on the outline of an object and applying a scaling or non-linear transformation to said values to arrive at a representation of the outline.

24. (New) A method as claimed is claim 23 wherein said numerical values are substantially invariant to the scale of the outline.

25. (New) A method as claimed is claim 23 wherein the number of said numerical values depends on the shape of the outline.

26. (New) A method as claimed in claim 23 wherein the scaling or non-linear transformation does not depend on the outline shape.

27. (New) A method as claimed in claim 23 wherein the numerical values reflect points of inflection on the outline.

28. (New) A method as claimed in claim 23 comprising deriving a curvature scale space representation of the outline by smoothing the outline in a plurality of stages using a smoothing parameter resulting in a plurality of outline curves, using values for feature points on each outline curve to derive curves characteristic of the original outline, and selecting the co-ordinates of peaks of said characteristic curves, wherein said transformation is applied to peak co-ordinate values.

29. (New) A method as claimed in claim 28 wherein the feature points relate to the curvature of each outline curve.

30. (New) A method as claimed in claim 29 wherein the feature points relate to the maxima and minima of the curvature of the outline curves.

31. (New) A method of representing an object appearing in a still or video image, by processing signals corresponding to the image, the method comprising deriving a curvature scale space representation of the object outline, selecting co-ordinates for peaks in the

curvature scale space, and applying a non-trivial transformation to peak co-ordinate values to arrive at a representation of the object outline.

32. (New) A method as claimed in claim 31 wherein the curvature scale space representation is such that peak co-ordinate values are substantially invariant to the scale of the object outline.

33. (New) A method as claimed in claim 31 wherein the transformation is applied to the co-ordinate values corresponding to a smoothing parameter in the CSS representation.

34. (New) A method as claimed in claim 31 wherein the transformation is applied to the co-ordinate values corresponding to an arc-length parameter along the outline.

35. (New) A method as claimed in claim 31 wherein the transformation is a scaling transformation.

36. (New) A method as claimed in claim 31 wherein the transformation is a non-linear transformation.

37. (New) A method as claimed in claim 35 wherein the transformation does not depend on the outline shape.

38. (New) A method as claimed in claim 23 wherein said transformation is in the form of $z^{1} = a\ pow\ (z,b) + c$, where a, b and c are constants and pow (z,b) denotes z to the power b.

39. (New) A method as claimed in claim 38 wherein b is greater than zero and less than 1.

40. (New) A method as claimed in claim 39 wherein b is in the range of $0.25 <= b <= 0.75$.

41. (New) A method as claimed in claim 40 wherein $b = 0.5$.

42. (New) A method as claimed is claim 41 wherein b = 0.6.

43. (New) A method for searching for an object in a still or video image by processing signals corresponding to images, the method comprising inputting a query in the form of a two-dimensional outline, deriving a descriptor of said outline using a method as claimed in claim 1, obtaining a descriptor of objects in stored images derived using a method as claimed in claim 1 and comparing said query descriptor with each descriptor for a stored object, and selecting and displaying at least one result corresponding to an image containing an object for which the comparison indicates a degree of similarity between the query and said object.

44. (New) An apparatus adapted to implement a method as claimed in claim 23.

45. (New) A computer program for implementing a method as claimed in claim 23.

46. (New) A computer system programmed to operate according to a method as claimed in claim 23.

47. (New) A computer-readable storage medium storing computer-executable process steps for implementing a method as claimed in claim 23.

48. (New) A method of representing objects in still or video images substantially as hereinbefore described with reference to the accompanying drawings.

49. (New) A method of searching for objects in still or video images substantially as hereinbefore described with reference to the accompanying drawings.

50. (New) A computer system substantially as hereinbefore described with reference to the accompanying drawings.--

REMARKS

Favorable consideration of this application, as presently amended, is respectfully requested.

The present preliminary amendment is submitted to place the above-identified application in more proper format under United States practice. By the present preliminary amendment original claims 1-22 are canceled and new claims 23-50 are presented for examination. New claims 23-50 are believed to be self-evident from the originally filed disclosure, and thus are not deemed to raise any issues of new matter.

The present application is believed to be in condition for a full and thorough examination on the merits. An early and favorable consideration of the present application is hereby respectfully requested.

Respectfully submitted,

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SPECIFICATION

Method, Apparatus, Computer program, Computer system and Computer-readable storage for Representing and Searching for an Object in an Image

Technical Field

The present invention relates to the representation of an object appearing in a still or video image, such as an image stored in a multimedia database, especially for searching purposes, and to a method and apparatus for searching for an object using such a representation.

Background Art

In applications such as image or video libraries, it is desirable to have an efficient representation and storage of the outline or shape of objects or parts of objects appearing in still or video images. A known technique for shape-based indexing and retrieval uses Curvature Scale Space (CSS) representation. Details of the CSS representation can be found in the papers "Robust and Efficient Shape Indexing through Curvature Scale Space" Proc. British Machine Vision conference, pp 53-62, Edinburgh, UK, 1996 and "Indexing an Image Database by Shape Content using Curvature Scale Space" Proc. IEE Colloquium on Intelligent

Databases, London 1996, both by F. Mokhtarian, S. Abbasi and J. Kittler, the contents of which are incorporated herein by reference.

The CSS representation uses a curvature function for the outline of the object, starting from an arbitrary point on the outline. The curvature function is studied as the outline shape is evolved by a series of deformations which smooth the shape. More specifically, the zero crossings of the derivative of the curvature function convolved with a family of Gaussian filters are computed. The zero crossings are plotted on a graph, known as the Curvature Scale Space, where the x-axis is the normalised arc-length of the curve and the y-axis is the evolution parameter, specifically, the parameter of the filter applied. The plots on the graph form loops characteristic of the outline. Each convex or concave part of the object outline corresponds to a loop in the CSS image. The co-ordinates of the peaks of the most prominent loops in the CSS image are used as a representation of the outline.

To search for objects in images stored in a database matching the shape of an input object, the CSS representation of an input shape is calculated. The similarity between an input shape and stored shapes is determined by comparing the position and height of the peaks in the respective CSS images using a matching algorithm.

A problem with the known CSS representation is that the peaks for a given outline are based on the curvature function which is computed starting from an arbitrary point on the outline. If the starting point is changed, then there is a cyclic shift along the x-axis of the peaks in the CSS image. Thus, when a similarity measure is computed, all possible shifts need to be investigated, or at least the most likely shift. This results in increased complexity in the searching and matching procedure.

Accordingly the present invention provides a method of representing an object appearing in a still or video image, by processing signals corresponding to the image, the method comprising deriving a plurality of numerical values associated with features appearing on the outline of an object starting from an arbitrary point on the outline and applying a predetermined ordering to said values to arrive at a representation of the outline. Preferably, said values are derived from a CSS representation of said outline, and preferably they correspond to the CSS peak values.

It has been found that by applying a transformation, especially to CSS values, as in the invention, object retrieval performance is improved.

Disclosure of Invention

A method of representing an object appearing in a still or video image, by processing signals corresponding to the image set forth in claim 1, the method comprises deriving a plurality of numerical values representing features appearing on the outline of an object and applying a scaling or non-linear transformation to said values to arrive at a representation of the outline.

In a method set forth in claim 2, the numerical values reflect points of inflection on the outline.

A method set forth in claim 3 comprises deriving a curvature scale space representation of the outline by smoothing the outline in a plurality of stages using a smoothing parameter resulting in a plurality of outline curves, using values for feature points on each outline curve to derive curves characteristic of the original outline, and selecting the co-ordinates of peaks of said characteristic curves, wherein said transformation is applied to peak co-ordinate values.

In a method set forth in claim 4, the feature points relate to the curvature of each outline curve.

In a method set forth in claim 5, the feature points relate to the maxima and minima of the curvature of the

outline curves.

A method of representing an object appearing in a still or video image, by processing signals corresponding to the image set forth in claim 6, the method comprises deriving a curvature scale space representation of the object outline, selecting co-ordinates for peaks in the curvature scale space, and applying a non-trivial transformation to peak co-ordinate values to arrive at a representation of the object outline.

In a method set forth in claim 7, the transformation is applied to the co-ordinate values corresponding to a smoothing parameter in the CSS representation.

In a method set forth in claim 8, the transformation is applied to the co-ordinate values corresponding to an arc-length parameter along the outline.

In a method set forth in claim 9, the transformation is a scaling transformation.

In a method set forth in claim 10, the transformation is a non-linear transformation.

In a method set forth in claim 11, the transformation is in the form of $z' = a\ pow\ (z,b) + c$, where a, b and c are constants and pow (z,b) denotes z to the power b.

In a method set forth in claim 12, b is greater than zero and less than 1.

In a method set forth in claim 13, b is in the range of $0.25 <= b <= 0.75$.

In a method set forth in claim 14, $b = 0.5$.

A method for searching for an object in a still or video image by processing signals corresponding to images set forth in claim 15, the method comprises inputting a query in the form of a two-dimensional outline, deriving a descriptor of said outline using a method as claimed in any one of claims 1 to 10, obtaining a descriptor of objects in stored images derived using a method as claimed in any one of claims 1 to 10 and comparing said query descriptor with each descriptor for a stored object, and selecting and displaying at least one result corresponding to an image containing an object for which the comparison indicates a degree of similarity between the query and said object.

An apparatus set forth in claim 16 is adapted to implement a method as claimed in any one of claims 1 to 15.

A computer program set forth in claim 17 implements a method as claimed in any one of claims 1 to 15.

A computer system set forth in claim 18 is programmed to operate according to a method as claimed in any one of claims 1 to 15.

A computer-readable storage medium set forth in claim 19 stores computer-executable process steps for implementing a method as claimed in any one of claims 1 to 15.

A method of representing objects in still or video images set forth in claim 20 is described with reference to the accompanying drawings.

A method of searching for objects in still or video images set forth in claim 21 described with reference to the accompanying drawings.

A computer system set forth in claim 22 is described with reference to the accompanying drawings.

Brief Description of the Drawings

Fig. 1 is a block diagram of a video database system;

Fig. 2 is a drawing of an outline of an object;

Fig. 3 is a CSS representation of the outline of Fig. 2;

Fig. 4 is a diagram illustrating the representation of a shape;

Fig. 5 is a drawing of the shape of an object;

Fig. 6 is a CSS representation of the shape of Fig. 5;

Fig. 7 is a transformed representation of the shape of Fig. 5; and

Fig. 8 is a block diagram illustrating a searching method.

Best Mode for Carrying Out the Invention

First embodiment

Fig. 1 shows a computerised video database system according to an embodiment of the invention. The system includes a control unit 2 in the form of a computer, a display unit 4 in the form of a monitor, a pointing device 6 in the form of a mouse, an image database 8 including stored still and video images and a descriptor database 10 storing descriptors of objects or parts of objects appearing in images stored in the image database 8.

A descriptor for the shape of each object of interest appearing in an image in the image database is derived by the control unit 2 and stored in the descriptor database 10. The control unit 2 derives the descriptors operating under the control of a suitable program implementing a method as described below.

Firstly, for a given object outline, a CSS representation of the outline is derived. This is done using the known method as described in one of the papers mentioned above.

More specifically, the outline is expressed by a representation $\Psi = \{(x(u), y(u), u \in [0, 1]\}$ where u is a normalised arc length parameter.

The outline is smoothed by convolving Ψ with an ID Gaussian kernel g(u, σ), and the curvature zero crossings of the evolving curve are examined at σ charges. The zero crossing are identified using the following expression for the curvature:

$$k(u,\sigma)=\frac{X_u(u,\sigma)Y_{uu}(u,\sigma)-X_{uu}(u,\sigma)Y_u(u,\sigma)}{(X_u(u,\sigma)^2+Y_u(u,\sigma)^2)^{3/2}}$$

where

$$X(u,\sigma)=x(u)*g(u,\sigma) \qquad Y(u,\sigma)=y(u)*g(u,\sigma)$$

and

$$X_u(u,\sigma)=x(u)*g_u(u,\sigma) \qquad X_{uu}(u,\sigma)=x(u)*g_{uu}(u,\sigma)$$

Here * represents a convolution and the subscripts represent derivatives.

The number of curvature zero crossings changes as σ changes, and when σ is sufficiently high Ψ is a convex curve with no zero crossings.

The zero crossing points are plotted on a graph , known as the CSS image space. This results in a plurality of characteristic curves. The peaks of the characteristic curves are identified and the corresponding co-ordinates are extracted and stored. In general terms, this gives a set of n co-ordinate pairs [(x1,y1), (x2,y2), ...(xn,yn)], where n

is the number of peaks, and xi is the arc-length position of the ith peak and yi is the peak height.

In this embodiment, a binomial filter with coefficients (1/4, 1/2, 1/4) is used as an approximation of a Gaussian filter with some reduction of computational complexity. The reduction in computational complexity results from convenient filter coefficients which can be efficiently implemented on a DSP or a general-purpose processor.

The peak values, or in other words, the y-component values for the peaks, are then processed further. More specifically, the y values are transformed using the transformation:

$$y' = a\ pow(y,b) + c \qquad (1)$$

where pow(y,b) denotes y to the power b.

This results in a new set of peak values [(x1, y'1), (x2, y'2) ... (xn, y'n)], which values are stored in the descriptor database as a descriptor of the outline.

As a specific example, the outline shown in Fig. 2 results in a CSS image as shown in Fig. 3. Details of the co-ordinates of the peaks of the curves in the CSS image are given in Table 1 below.

Peak Index	X	Y
1	0.124	123
2	0.68	548
3	0.22	2120
4	0.773	1001
5	0.901	678

Table 1.

The transformation given above is then applied, with a = 6, b = 0.5 and c = 0. In other words, the square root of the original y value is taken and multiplied by a constant. This results in the following values:

Peak Index	X	Y
1	0.124	67
2	0.68	140
3	0.22	276
4	0.773	190
5	0.901	156

Table 2.

Here, the values are rounded to the nearest integer, but other roundings can be used.

Second embodiment

Another example is shown in Fig. 4.

Fig. 5 shows another example of an object shape, in this case a turtle. Fig. 6 shows the CSS peaks for the shape of Fig. 5. Fig. 7 shows the transformed peaks of Fig.

6, using the transformation given in equation (1) above, with a = 6.5, b = 0.5 and c = 0.

The stored descriptors are used for searching purposes. The user initiates a search by drawing an object outline on the display using the pointing device (step 510). The control unit 2 then derives a CSS representation of the input outline (step 520) and then applies the transformation to the y values as described above (step 530). The resulting descriptor of the input outline is then compared with each stored descriptor in the descriptor database, known in the following as the model descriptors, using a known matching procedure (step 540).

The matching comparison is carried out using a suitable algorithm resulting in a similarity measure for each descriptor in the database. A known matching algorithm such as described in the above-mentioned papers can be used. That matching procedure is briefly described below.

Given two closed contour shapes, the image curve Ψi and the model curve Ψm and their respective sets of peaks {(xi1,yi1),(xi2,yi2),..,(xin,yin)} and {(xm1,ym1), (xm2,ym2), …,(xmn,ymn)} the similarity measure is calculated. The

similarity measure is defined as a total cost of matching of peaks in the model into peaks in the image. The matching which minimises the total cost is determined using a dynamic programming. The algorithm recursively matches the peaks from the model to the peaks from the image and calculates the cost of each such match. Each model peak can be matched with only one image peak and each image peak can be matched with only one model peak. Some of the model and or image peak may remain unmatched, and there is an additional penalty cost for each unmatched peak. Two peaks can be matched if their horizontal distance is less then 0.2. The cost of a match is the length of the straight line between the two matched peaks. The cost of an unmatched peak is its height.

In more detail the algorithm works by creating and expanding a tree-like structure, where nodes correspond to matched peaks:

1. Create starting node consisting of the largest maximum of the image (xik, yik) and the largest maximum of the model (xir,yir).

2. For each remaining model peak which is within 80 percent of the largest maximum of the image peaks create an

additional starting node.

3. Initialise the cost of each starting node created in 1 and 2 to the absolute difference of the y-coordinate of the image and model peaks linked by this node.

4. For each starting node in 3, compute the CSS shift parameter alpha, defined as the difference in the x (horizontal) coordinates of the model and image peaks matched in this starting node. The shift parameter will be different for each node.

5. For each starting node, create a list of model peaks and a list of image peaks. The list hold information which peaks are yet to be matched. For each starting node mark peaks matched in this node as "matched", and all other peaks as "unmatched".

6. Recursively expand a lowest cost node (starting from each node created in steps 1-6 and following with its children nodes) until the condition in point 8 is fulfilled. To expand a node use the following procedure:

7. Expanding a node:

If there is at least one image and one model peak left unmatched:

select the largest scale image curve CSS maximum

which is not matched (xip,yip). Apply the starting node shift parameter (computed in step 4) to map the selected maximum to the model CSS image - now the selected peak has coordinates (xip-alpha, yip). Locate the nearest model curve peak which is unmatched (xms,yms). If the horizontal distance between the two peaks is less then 0.2 (i.e: |xip-alpha- xms | < 0.2), match the two peaks and define the cost of the match as the length of the straight line between the two peaks. Add the cost of the match to the total cost of that node. Remove the matched peaks from the respective lists by marking them as "matched". If the horizontal distance between the two peaks is greater than 0.2, the image peak (xip,yip) cannot be matched. In that case add its height yip to the total cost and remove only the peak (xip,yip) from the image peak list by marking it as "matched".

Otherwise (There are only image peaks or there are only model peaks left unmatched):

Define the cost of the match as the height of the highest unmatched image or model peak and remove that peak from the list.

8. If after expanding a node in 7 there are no

unmatched peaks in both the image and model lists, the matching procedure is terminated. The cost of this node is the similarity measure between the image and model curve. Otherwise, go to point 7 and expand the lowest cost node.

The above procedure is repeated with the image curve peaks and the model curve peaks swapped. The final matching value is the lower of the two.

As another example, for each position in the ordering, the distance between the input x value and the corresponding model x value and the distance between the input y value and the corresponding model y value are calculated. The total distance over all the positions is calculated and the smaller the total distance, the closer the match. If the number of peaks for the input and the model are different, the peak height for the leftovers is included in the total distance.

The above steps are repeated for each model in the database (step 480).

The similarity measures resulting from the matching comparisons are ordered (step 490) and the objects corresponding to the descriptors having similarity measures indicating the closest match (i.e. here the lowest

similarity measures) are then displayed on the display unit 4 for the user (step 500). The number of objects to be displayed can be pre-set or selected by the user.

Third embodiment

An alternative embodiment will now be described. This embodiment is the same as the previous embodiment, except that a different transformation is used. More specifically, the y values are transformed using the transformation:

$$y' = a_0 + a_1 y.$$

In other words, a linear, scaling, transformation is applied.

Here, $a_0 = 41$, $a_1 = 0.19$.

In a variation, $a_0 = 0$ and $a_1 = 0.27$.

Different values of a_0 and a_1 can be used as appropriate.

The searching and matching procedure is essentially as described in the previous embodiment.

It has been found that applying a transformation, especially a linear transformation involving scaling or a non-linear transformation, as described above results in a descriptor which is less sensitive, eg to changes of shape outline within an object class, which consequently results in improved retrieval of objects.

In the embodiments described above, the transformation is applied to the CSS values before storing in the descriptor database 10. Alternatively, the CSS values can be stored in the database 10, and the transformation carried out as part of the searching process, before the matching procedure is performed.

In the described embodiments, the transformations are applied to the y-co-ordinate values. However, they may be applied to the x-co-ordinate values.

Industrial Applicability

A system according to the invention may, for example, be provided in an image library. Alternatively, the databases may be sited remote from the control unit of the system, connected to the control unit by a temporary link such as a telephone line or by a network such as the internet. The image and descriptor databases may be provided, for example, in permanent storage or on portable data storage media such as CD-ROMs or DVDs.

Components of the system as described may be provided in software or hardware form. Although the invention has been described in the form of a computer system, it could be implemented in other forms, for example using a dedicated chip.

Specific examples have been given of methods of representing a 2D shape of an object, here, using CSS representation, and of methods for calculating values representing similarities between two shapes but any suitable such methods can be used.

The invention can also be used, for example, for matching images of objects for verification purposes, or for filtering.

CLAIMS

1. A method of representing an object appearing in a still or video image, by processing signals corresponding to the image, the method comprising deriving a plurality of numerical values representing features appearing on the outline of an object and applying a scaling or non-linear transformation to said values to arrive at a representation of the outline.

2. A method as claimed in claim 1 wherein the numerical values reflect points of inflection on the outline.

3. A method as claimed in claim 1 or claim 2 comprising deriving a curvature scale space representation of the outline by smoothing the outline in a plurality of stages using a smoothing parameter resulting in a plurality of outline curves, using values for feature points on each outline curve to derive curves characteristic of the original outline, and selecting the co-ordinates of peaks of said characteristic curves, wherein said transformation is applied to peak co-ordinate values.

4. A method as claimed in claim 3 wherein the feature points relate to the curvature of each outline curve.

5. A method as claimed in claim 4 wherein the feature points relate to the maxima and minima of the curvature of the outline curves.

6. A method of representing an object appearing in a still or video image, by processing signals corresponding to the image, the method comprising deriving a curvature scale space representation of the object outline, selecting co-ordinates for peaks in the curvature scale space, and applying a non-trivial transformation to peak co-ordinate values to arrive at a representation of the object outline.

7. A method as claimed in claim 6 wherein the transformation is applied to the co-ordinate values corresponding to a smoothing parameter in the CSS representation.

8. A method as claimed in claim 6 wherein the transformation is applied to the co-ordinate values

corresponding to an arc-length parameter along the outline.

9. A method as claimed in claim 6 wherein the transformation is a scaling transformation.

10. A method as claimed in claim 6 wherein the transformation is a non-linear transformation.

11. A method as claimed in any one of claims 1 to 5 or 10 wherein said transformation is in the form of z' = a pow (z,b) + c, where a, b and c are constants and pow (z,b) denotes z to the power b.

12. A method as claimed in claim 11 wherein b is greater than zero and less than 1.

13. A method as claimed in claim 11 wherein b is in the range of 0.25 <= b <=0.75.

14. A method as claimed in claim 13 wherein b = 0.5.

15. A method for searching for an object in a still or

video image by processing signals corresponding to images, the method comprising inputting a query in the form of a two-dimensional outline, deriving a descriptor of said outline using a method as claimed in any one of claims 1 to 10, obtaining a descriptor of objects in stored images derived using a method as claimed in any one of claims 1 to 10 and comparing said query descriptor with each descriptor for a stored object, and selecting and displaying at least one result corresponding to an image containing an object for which the comparison indicates a degree of similarity between the query and said object.

16. An apparatus adapted to implement a method as claimed in any one of claims 1 to 15.

17. A computer program for implementing a method as claimed in any one of claims 1 to 15.

18. A computer system programmed to operate according to a method as claimed in any one of claims 1 to 15.

19. A computer-readable storage medium storing

computer-executable process steps for implementing a method as claimed in any one of claims 1 to 15.

20. A method of representing objects in still or video images substantially as hereinbefore described with reference to the accompanying drawings.

21. A method of searching for objects in still or video images substantially as hereinbefore described with reference to the accompanying drawings.

22. A computer system substantially as hereinbefore described with reference to the accompanying drawings.

ABSTRACT

A method of representing an object appearing in a still or video image, by processing signals corresponding to the image, comprises deriving the peak values in CSS space for the object outline and applying a non-linear transformation to said peak values to arrive at a representation of the outline.

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(81) 指定国 (国内): BR, CN, IN, JP, KR, MX, RU, US.

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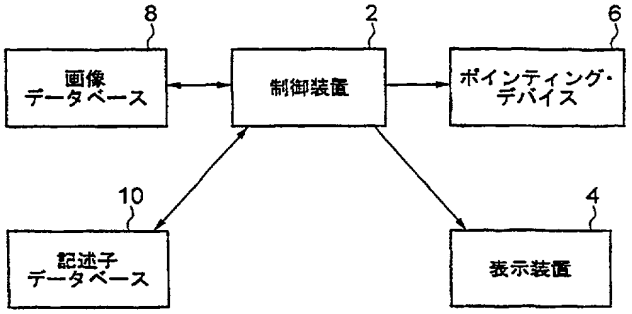
TITLE V

(54) Title: METHOD AND DEVICE FOR DISPLAYING OR SEARCHING FOR OBJECT IN IMAGE AND COMPUTER-READABLE STORAGE MEDIUM

(54) 発明の名称: 画像中のオブジェクトを表示する又は検索する方法、装置、及びコンピュータ可読記憶媒体



8: IMAGE DATABASE
2: CONTROLLER
6: POINTING DEVICE
10: DESCRIPTOR DATABASE
4: DISPLAY

(57) Abstract: A method for displaying an object appearing in an image by processing a signal corresponding to a still or video image comprising a step of deriving a peak value in a CSS space of the outline of an object and a step of displaying the outline by applying a nonlinear transformation to the peak value.

[続葉有]

WO 01/03069 A1

FIG. 1

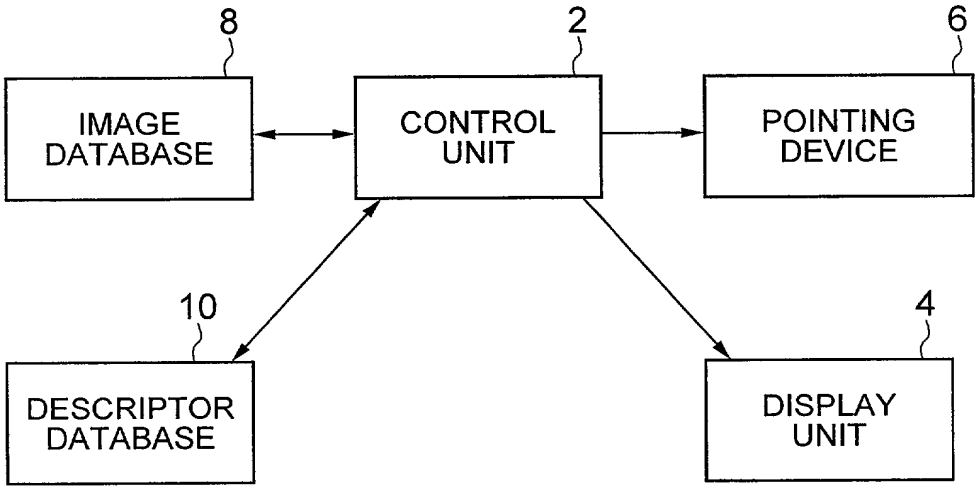

8
2
6
IMAGE DATABASE
CONTROL UNIT
POINTING DEVICE
10
4
DESCRIPTOR DATABASE
DISPLAY UNIT

FIG. 2

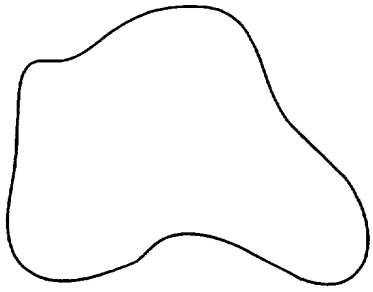


FIG. 3

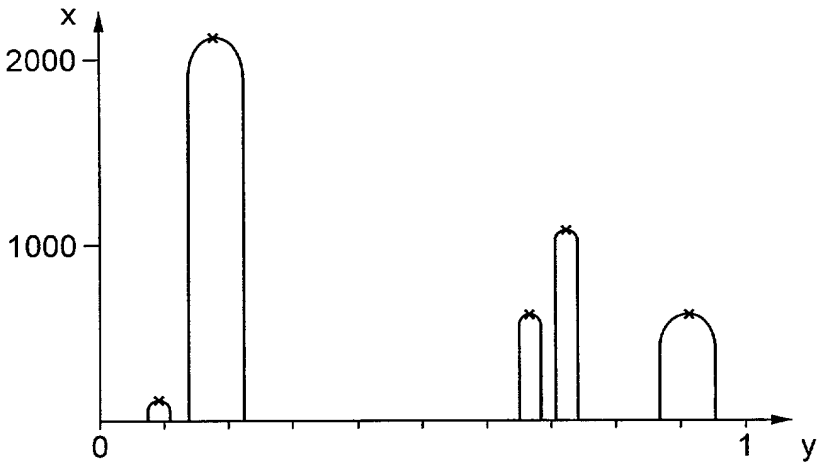


FIG. 4

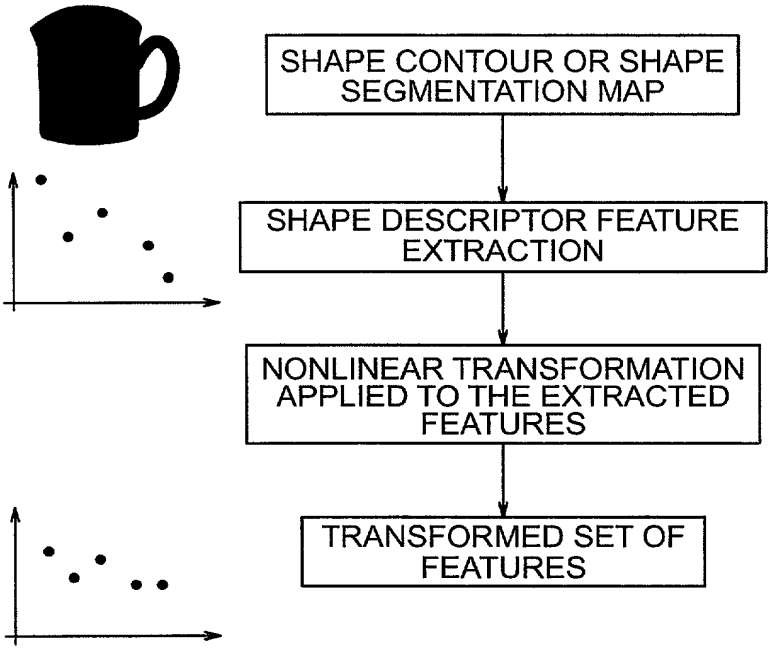

SHAPE CONTOUR OR SHAPE SEGMENTATION MAP
SHAPE DESCRIPTOR FEATURE EXTRACTION
NONLINEAR TRANSFORMATION APPLIED TO THE EXTRACTED FEATURES
TRANSFORMED SET OF FEATURES

FIG. 5

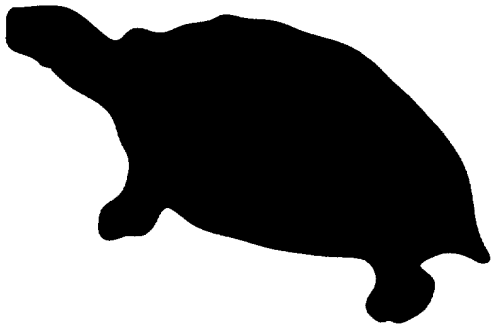


FIG. 6

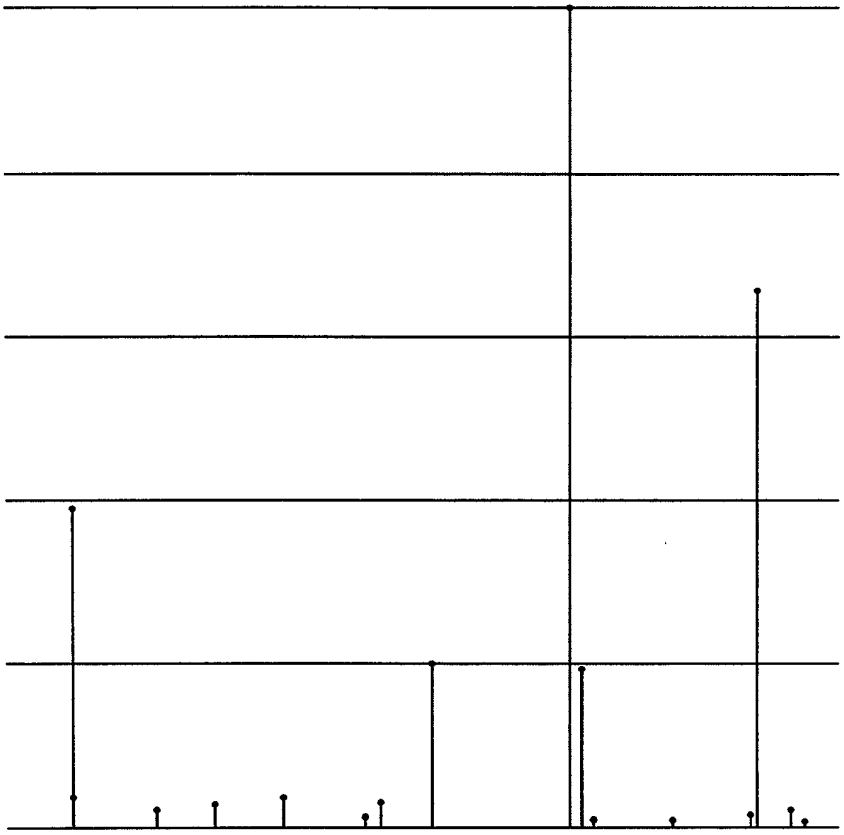


FIG. 7

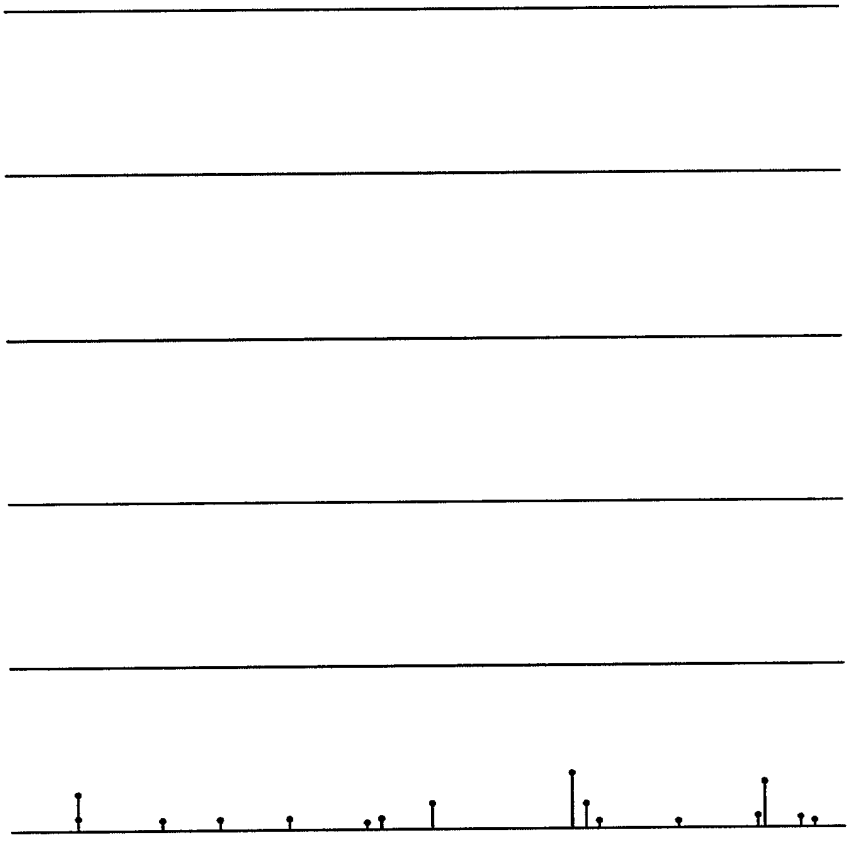
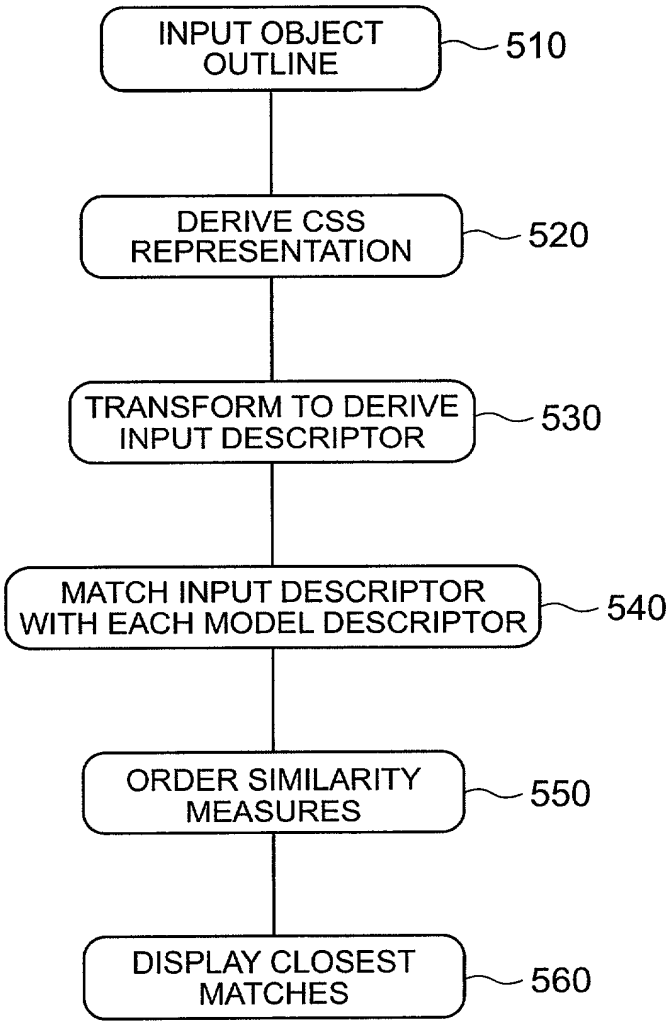


FIG. 8


INPUT OBJECT OUTLINE
510
DERIVE CSS REPRESENTATION
520
TRANSFORM TO DERIVE INPUT DESCRIPTOR
530
MATCH INPUT DESCRIPTOR WITH EACH MODEL DESCRIPTOR
540
ORDER SIMILARITY MEASURES
550
DISPLAY CLOSEST MATCHES
560

Declaration and Power of Attorney For Patent Application

特許出願宣言書及び委任状

Japanese Language Declaration

日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

My residence, post office address and citizenship are as stated next to my name.

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者（下記の名称が複数の場合）であると信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled.

METHOD, APPARATUS, COMPUTER PROGRAM, COMPUTER SYSTEM AND COMPUTER-READABEL STORAGE FOR REPRESENTING AND SEARCHING FOR AN OBFECT IN AN IMAGE

上記発明の明細書は、

the specification of which

☐ 本書に添付されています。

☐ is attached hereto.

☒ ____月____日に提出され、米国出願番号または特許協定条約国際出願番号を_____とし、
（該当する場合）_____に訂正されました。

☒ was filed on July 3, 2000
as United States Application Number or
PCT International Application Number
PCT/JP00/04401 and was amended on
_____ (if applicable).

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第37編第1条56項に定義されるとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

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私は、米国法典第35編119条（a）-（d）項又は365条（b）項に基づき下記の、米国以外の国の少なくとも一ヵ国を指定している特許協力条約365（a）項に基づく国際出願、又は外国での特許出願もしくは発明者証の出願についての外国優先権をここに主張するとともに、優先権を主張している、本出願の前に出願された特許または発明者証の外国出願を以下に、枠内をマークすることで、示しています。

I hereby claim foreign priority under Title 35, United States Code, Section 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s) 外国での先行出願			Priority Claimed 優先権主張	
9915699.4	U.K.	05 / 07 / 1999	☒ Yes はい	☐ No いいえ
(Number) (番号)	(Country) (国名)	(Day/Month/Year Filed) (出願年月日)		
			☐ Yes はい	☐ No いいえ
(Number) (番号)	(Country) (国名)	(Day/Month/Year Filed) (出願年月日)		

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(Application No.) (出願番号)	(Filing Date) (出願日)	(Application No.) (出願番号)	(Filing Date) (出願日)

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(Application No.) (出願番号)	(Filing Date) (出願日)	(Status: Patented, Pending, Abandoned) (現況：特許許可済、係属中、放棄済)
(Application No.) (出願番号)	(Filing Date) (出願日)	(Status: Patented, Pending, Abandoned) (現況：特許許可済、係属中、放棄済)

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Japanese Language Declaration
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委任状：私は下記の発明者として、本出願に関する一切の手続きを米特許商標局に対して遂行する弁理士または代理人として、下記の者を指名いたします。
(弁護士、または代理人の指名及び登録番号を明記のこと)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith: *(list name and registration number)*

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住所	Residence
国籍	Citizenship
郵便の宛先	Post Office Address

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